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AUTHOR Codding, Robin S.; Lewandowski, Lawrence; Gordon, Michael
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ABSTRACT

This study examined executive functioning (EF) in attention deficit hyperactivity disorder (ADHD) boys ages 6-12 on a parent-report measure from Barkley's model. Mothers of 40 boys (20 with ADHD-HI or ADHD-C, and 20 without ADHD) completed the ADHD Symptom Checklist (ADHD-SC4), Child Behavior Checklist (CBCL-P), School-Home Information Profile (SHIP), and Children's Inhibition and Executive Function Scale (ChIEFS). Significant differences were found between groups for all measures, with the ChIEFS total score being the most discriminating index of ADHD (97.5%). The ChIEFS factors were highly intercorrelated and related to total score, suggesting they were all measuring the same construct. Executive functions may tap one's ability to control oneself, whether that involves control of motor, memory, attention, motivation, or planning functions. Executive functions also seem to be important in assessing characteristics of ADHD, and could prove useful in conjunction with current diagnostic instruments. (Author)

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# Examining Executive Functioning in Boys with ADHD

By Robin S. Codding, M.S. & Lawrence Lewandowski, Ph.D.

Syracuse University

Michael Gordon, Ph.D.

SUNY Upstate Medical University

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Abstract

This study examined executive functioning (EF) in ADHD boys ages 6-12 on a parent-report measure developed from Barkley's model (1997). Mothers of 40 boys (20 with ADHD-HI or ADHD-C, and 20 without ADHD) completed the ADHD Symptom Checklist (ADHD-SC4), Child Behavior Checklist (CBCL-P), School-Home Information Profile (SHIP), and Children's Inhibition and Executive Function Scale (ChIEFS). Significant differences were found between groups for all measures, with the ChIEFS total score being the most discriminating index of ADHD (97.5%). The ChIEFS factors were highly intercorrelated and related to total score, suggesting they were all measuring the same construct. Executive functions may tap one's ability to control oneself, whether that involves control of motor, memory, attention, motivation, or planning functions. Executive functions also seem to be important in assessing characteristics of ADHD, and could prove useful in conjunction with current diagnostic instruments.

## Executive Functions in Boys with ADHD

A recent survey of the ADHD literature has suggested that in addition to attentional issues, which have long been considered characteristic of ADHD, executive function deficits also play a role. Tannock (1998) described in a review article, that executive functions characterized by poor self-regulation and behavioral inhibition have been indicated as cardinal impairments in ADHD. Cognitive and neurobiological models have attempted to re-conceptualize the disorder, the most comprehensive of which is Barkley's (1997a, 1997b, 1998). Yet, no studies have attempted to test this model directly, in its entirety, in children.

Research has demonstrated that children with ADHD have cognitive characteristics such as slow inhibitory processes, working memory deficits, delays in internalization of speech, poor self-regulation of emotion and motivation, and difficulty analyzing and synthesizing behavior. These deficiencies may make it difficult for children with ADHD to stop impulsive behaviors, to perform mental arithmetic or complete chores on time, follow parents' and teachers' rules, delay gratification, and engage in creative problem solving. Barkely's theoretical model illustrates how cognitive characteristics of ADHD relate to one another and to behavioral inhibition. This model postulates that behavioral inhibition is the primary deficit associated with ADHD and has a direct effect on behavior. Behavioral inhibition is operationalized by three functions, (1) inhibition of prepotent (dominant) responses (2) interruption of ongoing responses (3) interference control (protection of mental action from disruption). The latter two facets of behavioral inhibition are thought to be the source of perseveration and distractibility, respectively, that are associated with ADHD.

Deficits in behavioral inhibition also lead to secondary deficits in four executive functions: *nonverbal working memory, internalization of speech (verbal working memory), self-regulation of affect/motivation/arousal,* and *reconstitution.* Nonverbal working memory is defined by Barkley (1997c) as holding events in mind to guide later behavior and is comprised of two interacting processes, retrospective function (remembering past events) and prospective function (anticipating the future). These two interacting processes constitute hindsight and foresight, respectively. Children with ADHD that exhibit deficits in nonverbal working memory likely have difficulty with temporally organizing and monitoring their behavior. For example, children may have difficulty completing homework, household chores, or other tasks in a timely manner. Therefore, the immediate environment will influence behavior in children with ADHD rather than information learned in the past or future. This is evident when ADHD children engage in risky behavior or are unable to remember past consequences to their actions.

Inefficient internalization of speech, also considered by Barkley (1998) as the verbal working memory system, may be found with children who have ADHD. Operations associated with this system include self-description and self-reflection, self-questioning and problem-solving, rule-governed behavior (self-instruction), self-generated rules and meta-rules, reading comprehension, and moral reasoning and guidance of behavior.

Self-regulation of affect, motivation, and arousal is the third system that Barkley (1997b, 1997c, 1998) suggested may be impaired in children with ADHD. The operation of this system allows overt emotions directed at others to become self-directed and then

made covert. Emotion is considered a motivational state in which motivation progresses from operating as an overt to a covert function. As motivation becomes covert, intrinsic motivation, or persistence, is created.

The last executive function defined by Barkley is reconstitution. Two interacting processes also characterize this system namely, analysis and synthesis. Analysis is defined as taking old behavior apart and synthesis is conceptualized as recombining its units. Reconstitution is manifested in verbal and nonverbal fluency, rule creativity, goal-directed problem solving and the sequencing of behavior.

Deficits in the behavioral inhibition and executive function systems are manifested in everyday behaviors that can be observed and rated by parents who are sensitive to these actions. Specifically, executive function defects have an indirect effect on behavioral output, therefore making cross-temporal, goal-directed, and future-oriented behavior less evident in children with ADHD, which can be observed and rated by parents who are sensitive to these actions.

The purpose of the present study was to examine questions related to Barkley's theory (1997b, 1997c, 1998) of ADHD utilizing an adapted version of Barkley's self-report rating scale for adults that has been modified for children (parent-report format). The intention of the current study was two-fold: (1) to assess executive function problems associated with ADHD in comparison to typical children as purported by Barkley's theoretical model; (2) and determine whether support for Barkley's model can be identified using the ChIEFS. Children with ADHD, and children without any psychopathology were compared on a parent-report version of Barkley's measure to assess whether executive function problems are associated with ADHD as proposed by

Barkley's model. We attempted to determine whether the ChIEFS represented Barkley's model as separate constructs or a single construct. Lastly, the purpose of this study was to identify, preliminarily, whether executive functions provide additional information about ADHD that is not assessed using the DSM-IV or other behavior rating scales (e.g., CBCL/4-18).

## Method

### *Participants*

Forty mothers of boys between the ages of 6 and 12 years served as participants. Twenty boys were diagnosed as having ADHD-HI or ADHD-C and twenty typical boys who did not meet criteria for a psychiatric disorder, LD, ADHD or other impairments were included. Participants were recruited from area physicians, school districts, ADHD parent groups, and clinic settings.

All boys were required to meet the following criteria to be included in the study: (1) obtained a Full Scale IQ $\geq$ 80; (2) be absent of pervasive developmental disorders, hearing or vision impairments, physical challenges, documented brain injury or any other neurological disorders; (3) be placed in a regular education classroom (resource support acceptable); (4) do not have a documented learning disability; and (5) typical children should not have ADHD or other psychiatric disorders

To be included in the ADHD group, boys met the following criteria: (1) Diagnosed with ADHD-Combined Type or ADHD-Hyperactive-Impulsive Type by a trained clinician who utilizes DSM-IV criteria; and (2) obtained a criterion score that is positive for ADHD on the ADHD-SC4 (Gadow & Sprafkin, 1997).

For the ADHD group, the average age of the boys was 8.61 (*SD* = 1.80) and the average grade level was 3.25 (*SD* = 1.89). The ethnic composition of the boys in the ADHD group was as follows: 70% were Caucasian, 15% were biracial, and 5% were Hispanic. Ninety percent of the boys with ADHD were taking medication.

For the typical group, the average age of the boys was 8.02 (*SD* = 1.65) and the average grade level was 2.60 (*SD* = 1.67). All of the boys in the typical group were Cacuasian.

*Materials and Procedure*

Participants were required to complete a packet that contained three questionnaires and were presented in the following order: (a) the School-Home Information Profile (SHIP); (b) Children's Inhibition and Executive Function Scale (ChIEFS); the ADHD Symptom Checklist (ADHD-SC4) (Gadow & Sprafkin, 1997); and (d) the Child Behavior Checklist (CBCL-P).

*Measures*

The SHIP, a 41-item questionnaire, contains two sections designed to acquire demographic and school information from mothers. The school information section contains 26-items (e.g. has trouble completing schoolwork on time; performance on tests and homework varies) and asks mothers to rate their sons on a scale from 0 (*never/ rarely*), 1 (*sometimes*), 2 (*often*), 3 (*very often*), or *don't know*.

The ChIEFS is a 48-item parent report measure designed to test Barkley's (1997) model of ADHD that assesses behavior associated with 5 executive functions:(1) *behavioral inhibition* (e.g. children's ability to remain on task; make decisions impulsively), (2) *working memory* (e.g., have difficulty planning ahead; trouble with

mental arithmetic), (3) *self-regulation of emotion/motivation* (e.g. put off things until the last minute; become easily frustrated and angry), (4) *reconstitution* (e.g., ability to learn new activities; explain things in sequence), (5) *motor control* (e.g., has poor handwriting; is uncoordinated). Mothers were required to rate their children's behavior on a scale from 0 (*never/rarely*), 1 (*sometimes*), 2 (*often*), and 3 (*very often*).

The ADHD-SC4 (Gadow & Sprafkin, 1997) is a commonly used rating scale that screens for ADHD and Oppositional Defiant Disorder (ODD). This scale was used to confirm ADHD-HI and C diagnoses based on normative criteria.

The parent-report form of the CBCL/4-18 (Achenbach, 1991) is a commonly used questionnaire that measures children's behavioral and emotional functioning. For this study, mean comparisons (t-tests) between the ADHD and Typical groups using the obtained t-score from the Attention Scale of the CBCL/4-18 were computed. The Attention Scale was also used in a discriminant analysis to determine its sensitivity in diagnosing the two groups studied.

## Results

### *Reliability*

Test-retest reliability for the total score was adequate for the ChIEFS and the SHIP with reliability coefficients of .98 for both measures. Test-retest reliability coefficients for the subtest scores on the ChIEFS ranged from .86 (Reconstitution) to .97 (Self-Regulation of Emotion).

### *Group Comparisons*

Group differences were examined on the SHIP, ChIEFS, the ChIEFS subtests, and CBCL-P using t-tests for independent samples (2-tailed), where equal variances were not assumed. Levene's Test for equal variances was significant, indicating heterogeneity of

variance between the ADHD and Typical groups. Normal probability plots and examination of skewness and kurtosis statistics indicated that the ChIEFS and SHIP scores for the ADHD and Typical groups both were normally distributed. Table 1 illustrates highly significant differences between the ADHD and typical groups on all measures.

*Correlations*

Table 2 illustrates the relationship between the ChIEFS, the SHIP, and the CBCL-P Attention Problems Scale. Pearson-product moment correlations for the Attention Problems Scale and the ChIEFS Total score was .86, $p < .01$. The strength of this relationship suggests that these scales may be measuring similar constructs.

Examination of the relationship between the ChIEFS and the SHIP also reveals considerable overlap between measures, $r\ (N = 40) = .92$, $p < .01$, suggesting that using both measures during an assessment may provide redundant information. Table 2 also illustrates the relationship between the ChIEFS total and subscale scores (*range* = .89 to .98), the relationship between the subscales with each other (*range* = .80 to .95), and the relationship between the Attention Problems scale of the CBCL-P/4-18 (Achenbach, 1991) with the ChIEFS total and subscale scores (*range* = .80 to .86).

*Discriminant Analysis*

A discriminate analysis was conducted to examine the ability of the ChIEFS, the SHIP, and the CBCL/Attention Problems Scale to separate children who had been diagnosed with ADHD from typical children. Out of the three measured examined the ChIEFS performed the best as this scale was able to discriminate groups with 97.5% accuracy and making only one error (see Table 3). The CBCL/Attention Problems Scale

performed only slightly worse than the ChIEFS scale. Interestingly, although in isolation the SHIP did not perform as well as the ChIEFS or the CBCL/Attention Problems Scale, when all three measures were examined together groups were discriminated with 100% accuracy.

## Discussion

Preliminary support was provided for Barkley's (1997) theoretical model implicating executive function differences in children with and without ADHD. Boys with ADHD appear not only to have symptoms of inattention, hyperactivity, and impulsivity, but also have symptoms that are associated with "control processes" such as working memory, motivation, regulation of emotion, motor control, and behavioral inhibition. All of the EF factors on the ChIEFS seem very sensitive to difficulties of ADHD boys, however, the factors correlate highly with one another and the total score of the ChIEFS. While it is clear that these executive function scales are sensitive to ADHD, it is unclear whether the logical factors are empirically differentiable from each other and the total score. It may be that the ChIEFS measures a general construct of "self control" rather than separable executive functions.

The ChIEFS did appear to provide additional information regarding the symptoms of ADHD to some degree. The results from the discriminant analysis indicated that the ChIEFS total score is the best predictor of group membership in this study (97.5%), followed by the CBCL-Attention Problems scale (95%), and the SHIP (92.5%). However, the ChIEFS, SHIP, and CBCL-Attention Problems scale are highly inter-related and share similar questions rated by the same person. Therefore it seems that there is considerable redundancy in these measures. Given that the CBCL is well

established, we suggest using it as a diagnostic instrument for ADHD, and including more executive functions items in the next revision of the CBCL. It is possible that an executive functions scale such as the ChIEFS may help corroborate a diagnosis or offer descriptive information for purposes of treatment.

Further research is needed to test Barkley's EF model. Items and factors need to be based on empirical performance rather than logical or theoretical inclusion. Specifically, factor analytic and validity studies should be conducted. Until executive functions are better delineated as a construct or set of constructs, such measures will remain in the development stage.

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Table 1.

Mean Comparisons for ADHD and Typical Groups on Total and Factor Scores.

| Questionnaire | **ADHD** Mean (SD) n = 20 | **Typical** Mean (SD) n = 20 | Significant Difference |
|---|---|---|---|
| CBCL Attention Scale | 73.9 (9.9) | 51.2 (2.4) | $p<0.0001$ |
| SHIP Total Score | 48.5 (13.4) | 9.2 (7.7) | $p<0.0001$ |
| ChIEFS Total Score | 92.3 (21.5) | 26.9 (13.0) | $p<0.0001$ |
| Factor Scores | | | |
| BI | 17.3 (4.1) | 6.2 (3.1) | $p<0.0001$ |
| WM | 21.5 (6.0) | 4.4 (2.6) | $p<0.0001$ |
| SRE/M | 33.5 (6.9) | 11.8 (5.8) | $p<0.0001$ |
| R | 9.4 (4.5) | 2.1 (2.4) | $p<0.0001$ |
| MC | 10.7 (3.7) | 2.5 (1.8) | $p<0.0001$ |

*Note.* BI= Behavioral Inhibition; WM = Working Memory; SRE/M=Self Regulation of Emotion and Motivation; R=Reconstitution; MC=Motor Control. Two sample t-tests were computed with unequal variances assumed.

Table 2.

Correlations Among the SHIP, ChIEFS, and the CBCL Attention Scale.

| | Attention Scale | SHIP | ChIEFS | BI | WM | SRE/M | R | MC |
|---|---|---|---|---|---|---|---|---|
| Attention Scale | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| SHIP | 0.82 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| ChIEFS | 0.86 | 0.92 | ---- | ---- | ---- | ---- | ---- | ---- |
| BI | 0.80 | 0.92 | 0.96 | ---- | ---- | ---- | ---- | ---- |
| WM | 0.87 | 0.90 | 0.98 | 0.92 | ---- | ---- | ---- | ---- |
| SRE/M | 0.80 | 0.91 | 0.97 | 0.95 | 0.93 | ---- | ---- | ---- |
| R | 0.83 | 0.78 | 0.89 | 0.81 | 0.89 | 0.80 | ---- | ---- |
| MC | 0.82 | 0.81 | 0.91 | 0.85 | 0.86 | 0.86 | 0.82 | ---- |

*Note:* N = 40. All correlations are significant at $p < 0.01$ (2-tailed). BI= Behavioral Inhibition; WM = Working Memory; SRE/M=Self Regulation of Emotion and Motivation; R =Reconstitution; MC =Motor Control.

Table 3.

Percent Correct Group Classification as Determined by Discriminant Analyses

| Questionnaire(s) | Predicted Group Membership | | Percentage Correct |
|---|---|---|---|
| | **ADHD** | **Typical** | |
| | C/IC | C/IC | |
| | n = 20 | n = 20 | |
| CBCL/Attention Scale | 18/2 | 20/20 | 95.0 |
| SHIP | 17/3 | 20/20 | 92.5 |
| ChIEFS | 19/1 | 20/20 | 97.5 |
| CBCL/Attention*SHIP | 19/1 | 20/20 | 97.5 |
| CBCL/Attention*ChIEFS | 19/1 | 20/20 | 97.5 |
| SHIP*ChIEFS | 18/2 | 20/20 | 95.0 |
| CBCL/Attention*SHIP*ChIEFS | 20/20 | 20/20 | 100.0 |

*Note.* C = Number classified correctly; IC = Number classified incorrectly